

# **The Distribution of Ticks Across an Urban Landscape**

## **Within and Close to Austin, Texas**

Lauren C. Cybulska

\*Christopher Cormier

St. Edward's University

Austin, TX

**Abstract**

The goal of this research study was to measure the distribution of tick populations in public parks in and around Austin, Texas, and to determine whether there is a correlation between the presence of ticks and any environmental variables that were measured. Carbon dioxide (CO<sub>2</sub>) traps and tick drag nets were used to capture the tick samples. The variables that were measured include time, air temperature (°C), ground temperature (°C), humidity (%), underbrush level (0-4), light level (lux), wind speed (m/s) and direction, distance to water and roads, and the presence or absence of ticks in that area. Our seven study sites included the Bull Creek Greenbelt, Wild Basin Wilderness Preserve, Blunn Creek Nature Preserve, the Austin Nature & Science Center, the Barton Creek Greenbelt (Scottish Woods Trail and Zilker Park Access), Garlic Creek Park, and a wooded private property in Dripping Springs, TX. Although the overall number of ticks collected was relatively low ( $n = 14$ ) largely due to cold weather during the first half of this study, there did appear to be some correlations made between some variables and the presence or absence of ticks. Distance to road ( $R = .667$ ), distance to water ( $R = .445$ ), underbrush level ( $R = .309$ ), and ground temperature ( $R = .293$ ) had the greatest significance, respectively, when compared to tick presence/absence. These correlations will be explored further and in more detail throughout this paper.

## **Introduction**

Ticks and the diseases that they carry are a big problem across the United States. Many wildlife and domesticated animal species are targeted as hosts to be used for blood meals for these pests, thereby making them susceptible to acquiring the diseases that they carry. These blood meals are a necessity for the reproduction and advancing to the next life stage of these arachnids. The tick species whose geographic distribution include Central and Western Texas consist of the Blacklegged or Deer tick (*Ixodes scapularis*) (**Image 1**), Lone Star tick (*Amblyomma americanum*) (**Image 2**), American Dog Tick (*Dermacentor variabilis*) (**Image 3**), Brown Dog tick (*Rhipicephalus sanguineus*) (**Image 4**), and the Gulf Coast tick (*Amblyomma maculatum*) (**Image 5**).<sup>1, 2</sup> Tick-borne diseases and their pathogens which have been positively identified in these areas include Lyme Disease (*Borrelia burgdorferi*), Rocky Mountain Spotted Fever (*Rickettsia rickettsii*), Southern Tick Associated Rash Illness (“STARI”, arguably caused by the bacterium *Borrelia lonestari*), and Ehrlichiosis (*Ehrlichia chaffeensis*).<sup>3</sup>

Ticks have been known as disease-causing ectoparasites dating as far back as 1550 B.C., where references to ticks and “tick fever” were mentioned on an ancient Egyptian papyrus scroll. Philosophers such as Cato and Aristotle even mentioned ticks in some of their work, describing them as “disgusting parasitic animals” and were aware of the damage caused by them. However, it wasn’t until the end of the nineteenth century that the magnitude of the problem was truly understood when Smith and Kilbourne (1893) discovered that Boophilus ticks transmit the Texas fever pathogen, Babesia bigemina. This opened up a whole new world that led to the discovery of many other pathogenic filarial, protozoa, bacteria, rickettsiae, and viruses which are spread by ticks.<sup>4</sup>

### **Ticks of Texas and Their Geographic Distributions<sup>2</sup>**



**Image 1.** Blacklegged Tick  
(*Ixodes scapularis*)



**Image 2.** Lone Star Tick  
(*Amblyomma americanum*)



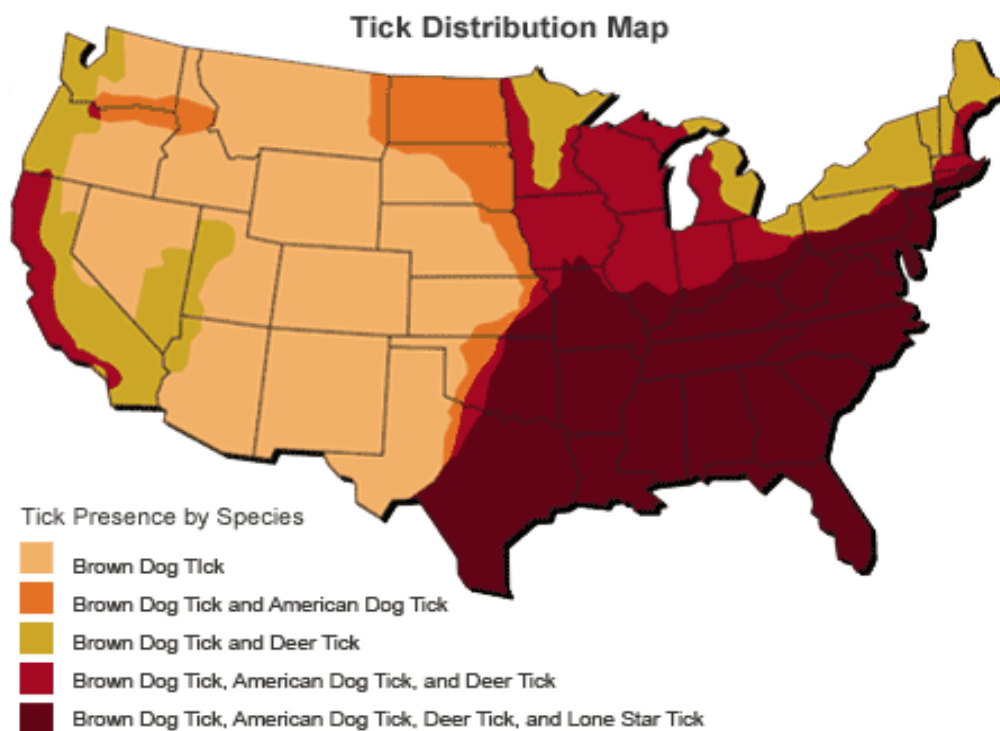
**Image 3.** American Dog Tick  
(*Dermacentor variabilis*)



**Image 4.** Brown Dog Tick  
(*Rhipicephalus sanguineus*)



**Image 5.** Gulf Coast Tick  
(*Amblyomma maculatum*)



**Figure 1.** Geographic distribution of several ticks in the United States.



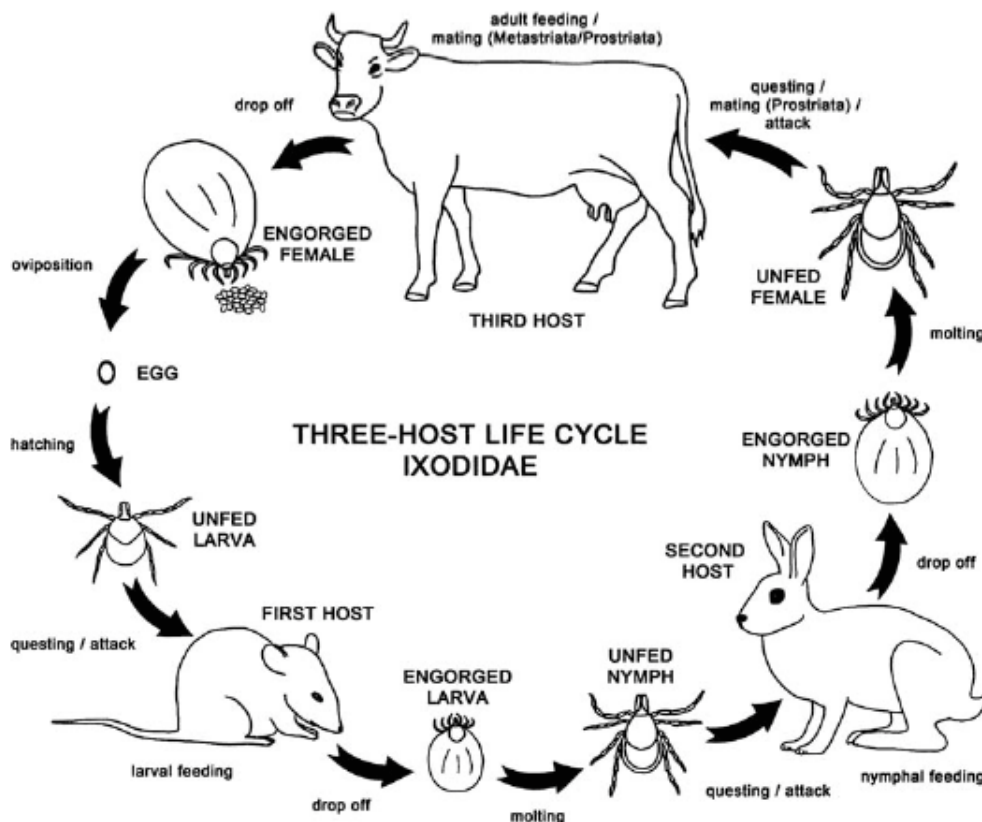
**Figure 2.** Geographic distribution of the Gulf Coast Tick in the Southern United States.

“Ticks far surpass all other arthropod species in the number and variety of diseases which they can transmit to domestic animals, and they rank second next to mosquitoes as vectors of human diseases”.<sup>5</sup> The disease agents can be transmitted directly to their hosts during hematophagy (blood-feeding) and also trans-ovarially to their offspring, making them an even greater threat to local and global public health as they are both vectors and reservoirs for these diseases. The monetary impact that ticks may cause, ranges in the thousands of millions of dollars. This includes the global economic impact from cattle death or decreased productivity and the cost of controlling ticks and tick-borne diseases. However, it does not include the harm caused to the environment by chemical pesticides preventing tick infestations, which can also cause toxic residues in meat, milk, and their by-products.<sup>5</sup>

Ticks have a life cycle that consists of 4 developmental stages. The egg is the only non-parasitic stage, while there are 3 other active parasitic stages (larva, nymph, and adult [male and female]). All hard ticks (family Ixodidae) consist of the egg and 3 active parasitic stages. Each of the active stages only needs to feed once in its life. Ticks can either have a 3-, 2-, or 1-host cycle. Depending on the circumstances, some species can behave as a 3-, 2-, or a 1-host tick. Most ixodid ticks (which are the kind most typically found in Texas) have a 3-host cycle (**Figure 3**). This means that they must drop off the host between life stages in order to develop to their next stage. 2-Host ticks have only two hosts during their life cycle, and remain on the same host between two developmental stages. 1-Host ticks remain on the same host throughout all of their life stages, and males will mate with females on the host.<sup>6</sup>

In the 3-host ixodid, the larvae drop off from the host after feeding and molt to the nymphal stage. The unfed nymphs quest for a host and may attach to the same or different hosts, feed, drop off, and molt to the adult stage. The adult males will feed briefly, then spend a

majority of their time searching for females to mate with. The female adults mate, find a host, feed, drop off the host, lay eggs and die.<sup>6</sup> In the tick's parasitizing life stages it uses a long tube-like structure that it inserts into the host called the hypostoma. The hypostoma's harpoon-like barbs are aided by a secreted, cement-like substance that forms a tight attachment between the tick and its host's skin.<sup>7</sup>



**Figure 3.**  
Three-host life cycle of Ixodidae ticks.<sup>6</sup>

However, a female that is forcibly detached from its host can reattach to another host and finish their blood meal if they have not reached their maximum weight, which can be up to 100 times the pre-feeding weight of the female. If a female has reached a “critical mass” (point at which she has fed enough to be able to produce eggs) when she is forcibly detached, she can either reattach to a host to finish her blood meal, or she may be able to produce some eggs. A female that has reached full engorgement will drop off the host and deposit her eggs in burrows, crevices, or leaf litter. This will last for several weeks, after which she will stay alive for several

days, and then die. An ixodid tick can produce anywhere from a few hundred, to several thousand eggs (the most ever recorded was over 36,000 in *Amblyomma variegatum* in 1980).<sup>6</sup>

The three main objectives of this study were to estimate tick distribution in seven urban preserves across Central Texas with a focus on Travis County; examine environmental variation and correlation between tick presence and absence; and collect ticks to screen for diseases. One of the main reasons behind studying these ectoparasites in Austin is that there are few studies done on the subject in this part of Texas. We wanted to help assess the risk of getting tick bites and illnesses within several Central Texas urban parks in, or close to, Austin. Lyme disease in particular is a topic that needs to be examined more in this part of Texas. Austin's population has grown by 3.3% from April 2010 to July 2014, and in March 2015 was the third fastest-growing metro area by percent change in the U.S.<sup>8</sup> Ahead of Austin were two other metro areas – The Villages, Florida, and Myrtle Beach, South Carolina.

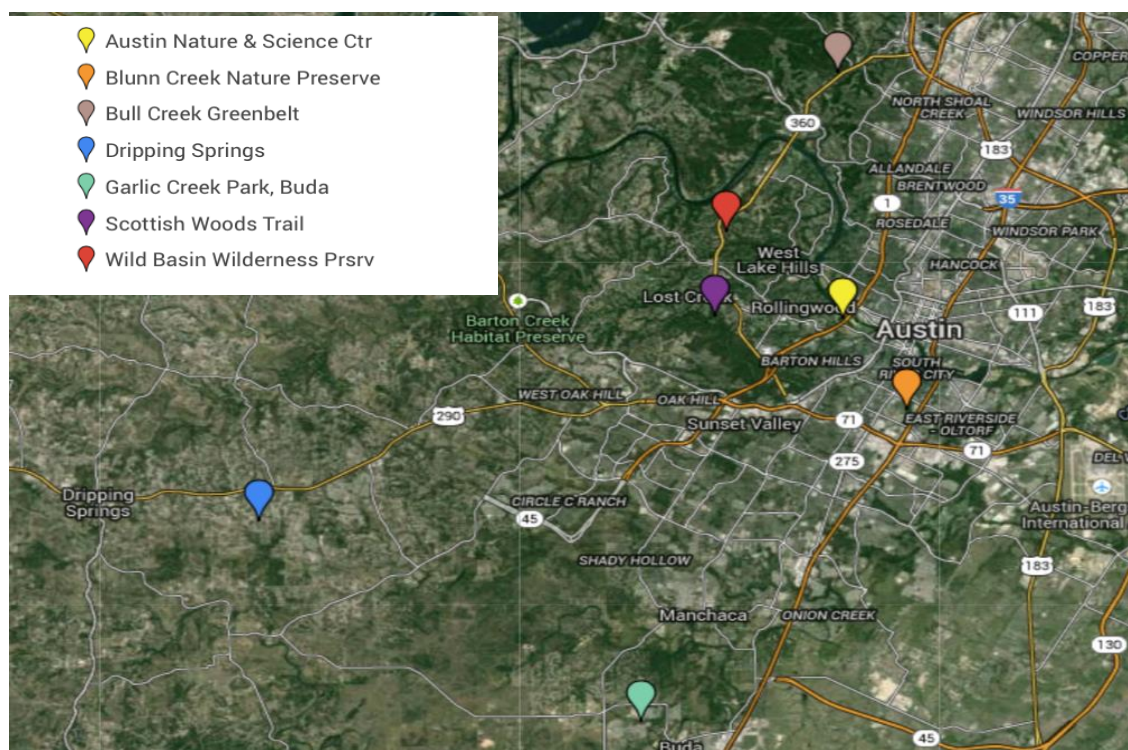
With that being said, Austin's growing human population is also likely to result in an increased dog population. Since dogs are also potential carriers of Lyme disease and other arthropod-borne diseases<sup>9</sup>, and considering the study sites for this project have high levels of daily foot traffic by both dogs and people<sup>10</sup>, it is of even greater importance to track the potential risk of exposure to these diseases in these parks.

### **Statement of Purpose**

As previously mentioned, there were three main objectives of this study. The first objective was to estimate tick distribution in seven urban preserves across Austin, Texas. The study sites included the Bull Creek Greenbelt, Wild Basin Wilderness Preserve, Blunn Creek



Nature Preserve, the Austin Nature & Science Center, the Barton Creek Greenbelt (Scottish Woods Trail), Garlic Creek Park, and a wooded private property in Dripping Springs, TX (**Figure 4**). The second objective was to examine environmental variation and correlation between tick presence and absence. The variables that were measured included time, air temperature ( $^{\circ}\text{C}$ ), ground temperature ( $^{\circ}\text{C}$ ), humidity (%), underbrush level (0-4), light level (lux), wind speed (m/s) and direction, distance to water or roads, and the presence or absence of ticks. The third objective was to collect ticks to screen for diseases, which were then to be sent to the University of North Texas to determine if there are any diseases present in those specimens.



Our seven study sites provided us with a wide variety of locations ranging from residential neighborhoods with heavy foot traffic by both people and dogs, to densely wooded areas, and pristine nature preserves. First is the Bull Creek Greenbelt, which is made up of 477 acres of lush green shrubbery, extensive hiking and biking trails, has a large creek that flows through the middle of the Greenbelt, and is frequented by both hikers and their pets.<sup>11, 12</sup> Wild Basin Wilderness Preserve is owned jointly by Travis County and St. Edward's University. It

consists of 227 acres of pristine woodlands, and pets are not allowed to accompany the hikers along the 2.5 miles of hiking trails.<sup>11</sup> Blunn Creek Nature Preserve covers 38 acres of land adjacent to St. Edward's University, and contains a large 1-mile loop trail with some branching, two creek crossings, and scenic overlooks. This site has low levels of hikers frequenting the trails, however there is a homeless population that resides in the dense woods of the preserve.<sup>10,11</sup>

Austin Nature & Science Center is an 80-acre nature center which is located in Zilker Park. The Center is very busy and is a popular location for families and children to come and visit.<sup>10</sup> The Barton Creek Greenbelt was examined during our study at two separate sites – the Scottish Woods Trail Access, and the Zilker Park Access. Garlic Creek Park is 31-acre public park located in a residential neighborhood in Buda, Texas just outside of Austin. It is comprised of a playground, recreation area, and biking/hiking trails with lush, tall grass and a creek that splits the park in half. This park has high numbers of visitors and dogs that go through its trails. There was also a great deal of evidence that deer frequented the site.<sup>13</sup> The last study site was on a wooded private property in Dripping Springs, Texas which is about 20 miles away from downtown Austin. This was a very densely wooded area with a lot of tree cover and low-growing vegetation, few human or canine visitors, and was frequented by deer.

## **Methods**

The primary methods that were practiced during this project involve the use of tick drag net traps and carbon dioxide traps. Each of these mechanisms exploits two separate behaviors that the ticks display. "Questing" is when a tick is actively seeking a host for a blood meal.<sup>14</sup> Some species of ticks remain sedentary when searching for hosts, staying in areas such as nests where birds or reptiles are likely to frequent. Meanwhile, tick species that are found in Texas will typically seek out game trails and other areas where animal/host presence is common. The scents

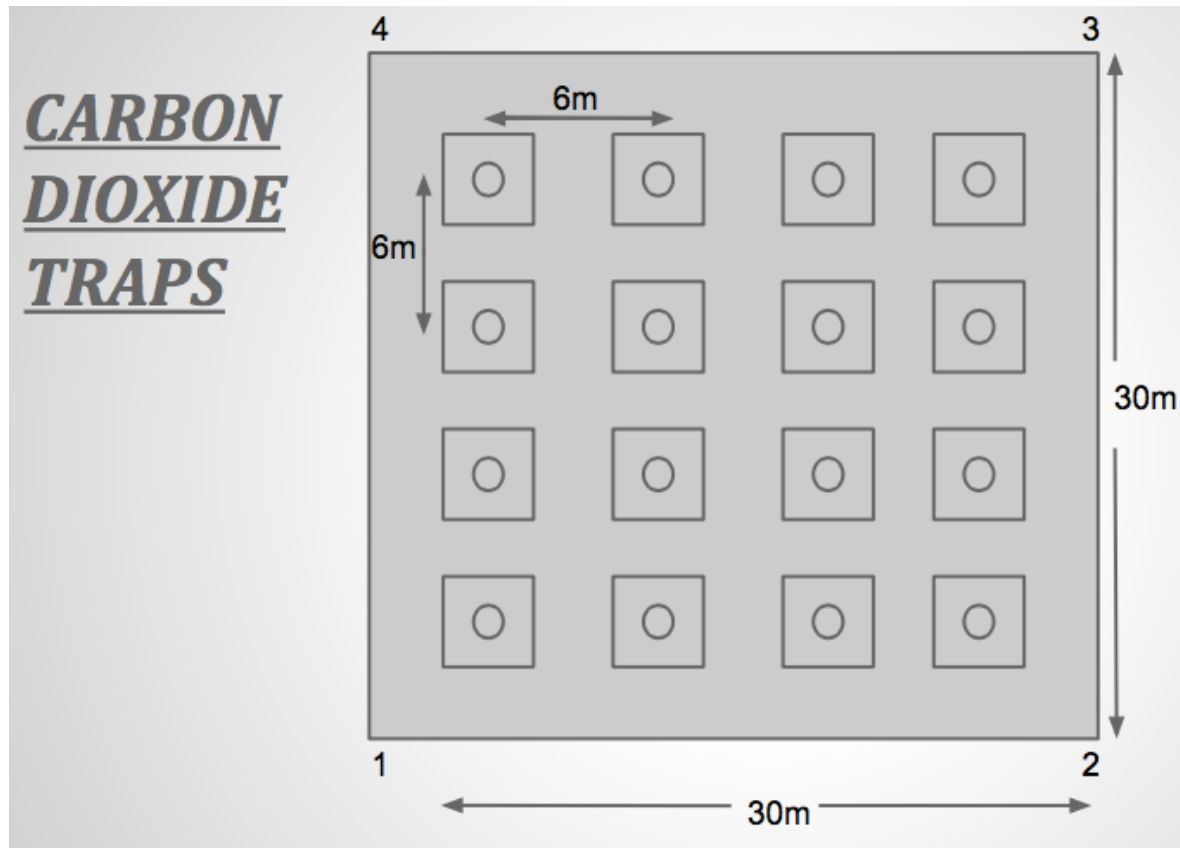
of these animals that have been left behind attract ticks, and the ticks will crawl to the edge of a blade of grass or a limb and wait with their front legs outstretched for a potential “ride” to pass by. The ticks then latch onto the animal’s hair (or clothes), and crawl under the coat to get to a warm covered area where the skin is typically much thinner (such as behind the ear or on the scalp).<sup>6</sup>



**Figure 5.** Using a device that is comprised of a white sheet, two metal rods, and an attached rope, the researchers pull the tick drag net in a zig-zag-like motion through the brush. The sheet is checked every five meters for ticks.

Tick dragging involves dragging a 4’x3’ white corduroy sheet connected by two metal rods and a rope on one end through vegetated areas of the study site. One end of the drag net is weighted down with heavy metal sinkers to help keep the device close to the ground. The dragging is done in a zig-zag grid-like motion (**Figure 5**), where those dragging cover a large distance in each direction. The apparatus is dragged along the ground in tall grass, through brush, and on trails within the given plot. The nets are checked very carefully every five meters for any ticks. This exploits the behavior where ticks travel to the edge of a blade of grass, and stand at the edge of it with its’ front legs outstretched. Once a host passes by and brushes against the

grass, the tick latches onto the host and can then parasitize it.<sup>6,15</sup>



**Figure 6.** Carbon Dioxide traps are set up 6 meters apart from each other in each direction in a 30m x 30m grid.

Another behavior that is displayed by ticks is their attraction to carbon dioxide – a compound that is released during respiration. When we exhale, we are releasing carbon dioxide, and have the potential to attract the arthropods. Carbon dioxide traps are meant to exploit the CO<sub>2</sub>-honing abilities of ticks. Dry ice is a substance that releases the compound when sublimating from a solid to a vapor. Sixteen 1-gallon ventilated coolers are baited with a pound of dry ice apiece. When baited with a pound of ice per cooler, the ice would last an average of 8-12 hours per trap. Each cooler is placed in the center of a 2ft x 2ft plywood board, fitted with double-sided carpet tape around the perimeter of the board. The ticks get stuck on the strong adhesive tape while traveling towards the baited coolers. The traps are set at six meters apart in a

30m x 30m grid (**Figure 6**). The reason for this distance is that most ticks will travel six meters to get to a host.<sup>15,16,17,18</sup> When repeating a second round at each of the seven sites, we randomized the traps rather than setting them in a grid to increase the area that the traps covered.

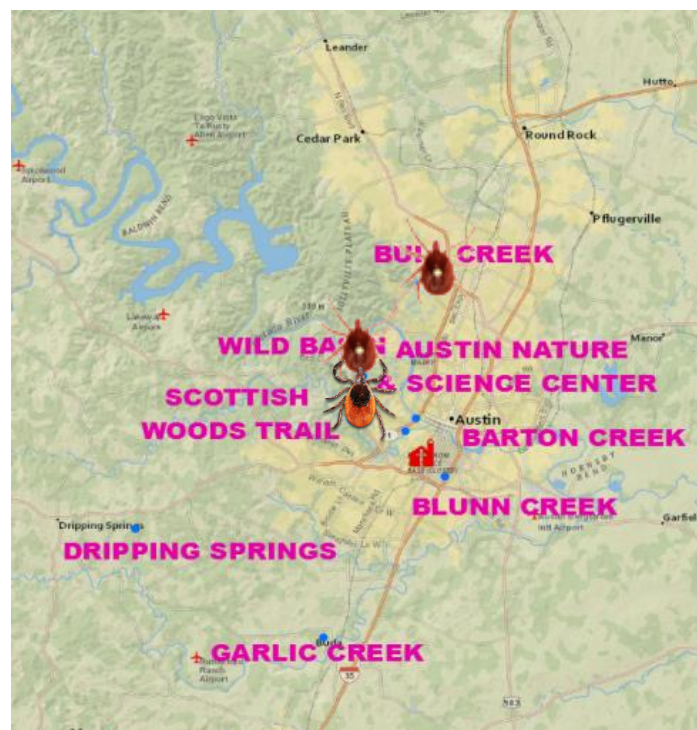
CO<sub>2</sub> traps were set up for an average of six to ten hours, with microhabitat environmental readings being taken at each trap every two hours. Tick dragging would be performed in between the readings, covering large areas around the CO<sub>2</sub> trap plots. At the Barton Creek Greenbelt the Zilker Park Access was only dragged once during the preliminary testing, and once again during the primary testing period in the Spring 2015. This was done because the Barton Creek permit only allowed dragging in this specific area as a precaution against potential reports to the Austin Police Dept. from concerned park visitors, as this plot had the highest levels of human foot traffic.

The variables that were measured include time, air temperature (°C), ground temperature (°C), humidity (%), underbrush level (0-4), light level (lux), wind speed (m/s) and direction, distance to water and roads, and the presence or absence of ticks in that area. A hygrometer/thermometer was used to measure ambient temperature and humidity; an infrared gun was used for ground temperature; the light level was measured using a light/lux meter in an app on an Android phone with 95% (+/- 1%) accuracy; a wind speed meter was used to measure the maximum temperature throughout the day, and a compass was used to determine the direction of the wind. ArcGIS would be used to measure the distance to road and water from each site.

Each of these variables was used to measure the microclimate of each trap every two hours, as well as the presence or absence of ticks at that particular trap. We expected to find a

correlation between the varying macro- and micro- climates across the Austin area, and the spatial distribution of tick species and disease. We hypothesized that there would be a correlation between the spatial distribution of tick species and disease, when compared to the climate, vegetation, and sunlight vs. shaded (microhabitats) present in those areas. One of our hypotheses was that there would be a correlation between the proximity to roads or water and the number of ticks found in those areas. Ticks that are collected would be stored in scintillation vials filled with 100% ethanol<sup>17,18</sup>, and shipped for disease screening to Dr. Michael S. Allen, PhD in Forth Worth, TX. Dr. Allen is the director of the Department of Molecular and Medical Genetics, in the Center for Biosafety and Biosecurity at the University of North Texas Health Science Center.

## Results





**Map1.** Study sites where ticks were found include Barton Creek, Wild Basin, and Bull Creek.

There are seven sites that were studied including the Bull Creek Greenbelt (BUC), Wild Basin Wilderness Preserve (WB), Blunn Creek Nature Preserve (BC), the Austin Nature & Science Center (ANSC), the Barton Creek Greenbelt Scottish Woods Trail (SWT) and Zilker Park Access (BCZP), Garlic Creek Park (GC), and a wooded private property in Dripping Springs, TX (DS). We found ticks at the Barton Creek Greenbelt, Wild Basin, and Bull Creek. The total sample size ( $n = 11$ ) includes three Blacklegged nymphs from tick dragging two to three miles from the Zilker Park Access during preliminary testing in the Fall; one Blacklegged adult male tick at the Scottish Woods Trail in the Spring; one adult female Lone Star tick at Bull Creek; two nymphs, three adult females, and one adult male Lone Star tick at Wild Basin.

The measured variables that had the greatest correlation when compared to tick presence/absence include: distance to road ( $R = .667$ ), distance to water ( $R = .445$ ), underbrush level ( $R = .309$ ), and ground temperature ( $R = .293$ ).

Ticks Pres = 1 Abs = 0	Study Site / Plot #	Distance to Roads (Meters)	Distance to Water (Meters)
1	BCZP / Prelim	124	8
0	BC / 1	268	107
0	BC / 2	348	23

Ticks Pres = 1 Abs = 0	Study Site / Plot #	Distance to Roads (Meters)	Distance to Water (Meters)
0	BC / 3	82	166
1	SWT / 1	1402	85
0	DS / 1	133	25
1	BUC / 1	150	81
0	ANSC / 1	41	125
0	GC / 1	100	19
0	GC / 2	195	89
0	WB / 1	141	141
1	WB / 2	516	221
1	WB / 3	516	221
0	BCZP / Drag	124	8

**Figure 7.** All distances measured between each site and the closest road or water source, and the tick presence/absence status within each plot.



Distance to road had the greatest significance out of all of the other variables. It had a P-value of .000, a correlation coefficient of  $R = .667$ , with a coefficient of 548. This means that for every 548 meters further from the road that you get, the more likely you will be to find a tick (*Figure 8*).

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.666 <sup>a</sup>	.444	.443	286.91268

**ANOVA**

	Regression	42451200.559	1	42451200.559	515.692	.000 <sup>b</sup>
1	Residual	53177999.441	646	82318.885		
	Total	95629200.000	647			

a. Dependent Variable: DISTANCEROAD

b. Predictors: (Constant), TICKSPRSESNECEN

**Coefficients<sup>a</sup>**

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	155.909	13.678		11.399	.000
TICKSPRSESNECEN	548.245	24.142	.666	22.709	.000

**Figure 8.** Distance to road - simple linear regression analysis.

Distance to water had the second greatest significance out of all of the other variables. It had a P-value of .000, a correlation coefficient of  $R = .445$ , with a coefficient of 63. This means that for every 63 meters you get further away from the primary water source, the more likely you are to find a tick (*Figure 9*).

**Coefficients<sup>a</sup>**

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	83.145	2.857		29.103	.000
TICKSPRSESNECEN	63.701	5.043	.445	12.633	.000

**ANOVA<sup>a</sup>**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	573098.677	1	573098.677	159.580	.000 <sup>b</sup>
	Residual	2319969.768	646	3591.284		
	Total	2893068.444	647			

**Coefficients<sup>a</sup>**

Model	95.0% Confidence Interval for B	
	Lower Bound	Upper Bound
1 (Constant)	77.535	88.755
TICKSPRSESNECEN	53.799	73.603

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.445 <sup>a</sup>	.198	.197	59.92733

a. Dependent Variable: DISTANCEWATER

b. Predictors: (Constant), TICKSPRSESNECEN

**Figure 9.** Distance to water - simple linear regression.

Underbrush level had the third greatest significance out of all of the variables. It had a P-value of .000, a correlation coefficient of  $R = .309$ , with a coefficient of  $-.602$ . This means that when using the scale of 0-4 to measure underbrush level (0 = no underbrush, 4 = very tall & thick underbrush), for every 0.6 that by which the 0-4 scale decreases, the more likely you are to find a tick (*Figure 10 & Figure 11*).

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.309 <sup>a</sup>	.095	.094	.86685		
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	51.215	1	51.215	68.157	.000 <sup>b</sup>
	Residual	485.426	646	.751		
	Total	536.642	647			

a. Dependent Variable: UNDERBRUSH

b. Predictors: (Constant), TICKSPRSESNECEN

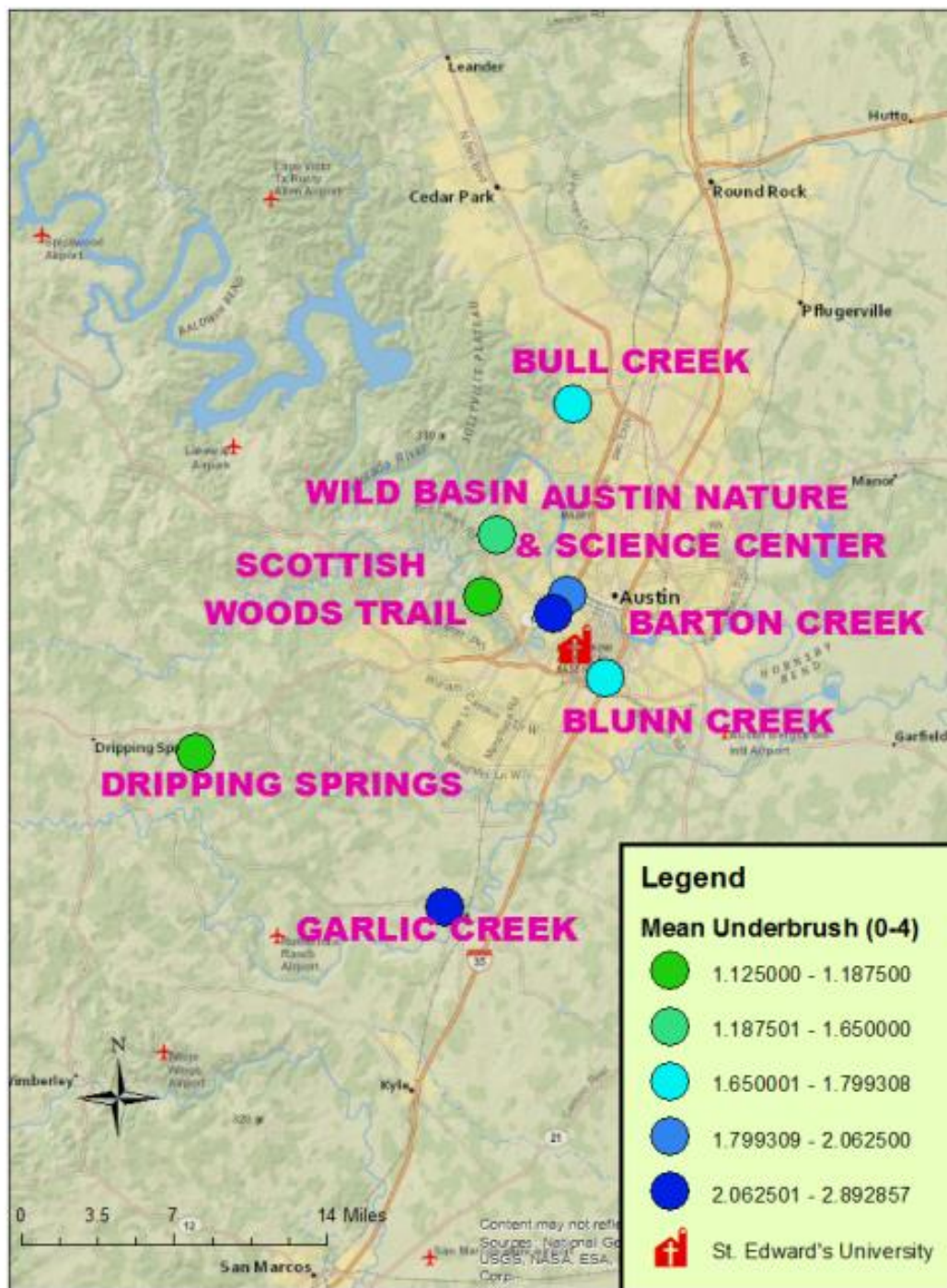
**Coefficients<sup>a</sup>**

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	2.020	.041		48.891	.000
TICKSPRSESNECEN	-.602	.073	-.309	-8.256	.000

**Coefficients<sup>a</sup>**

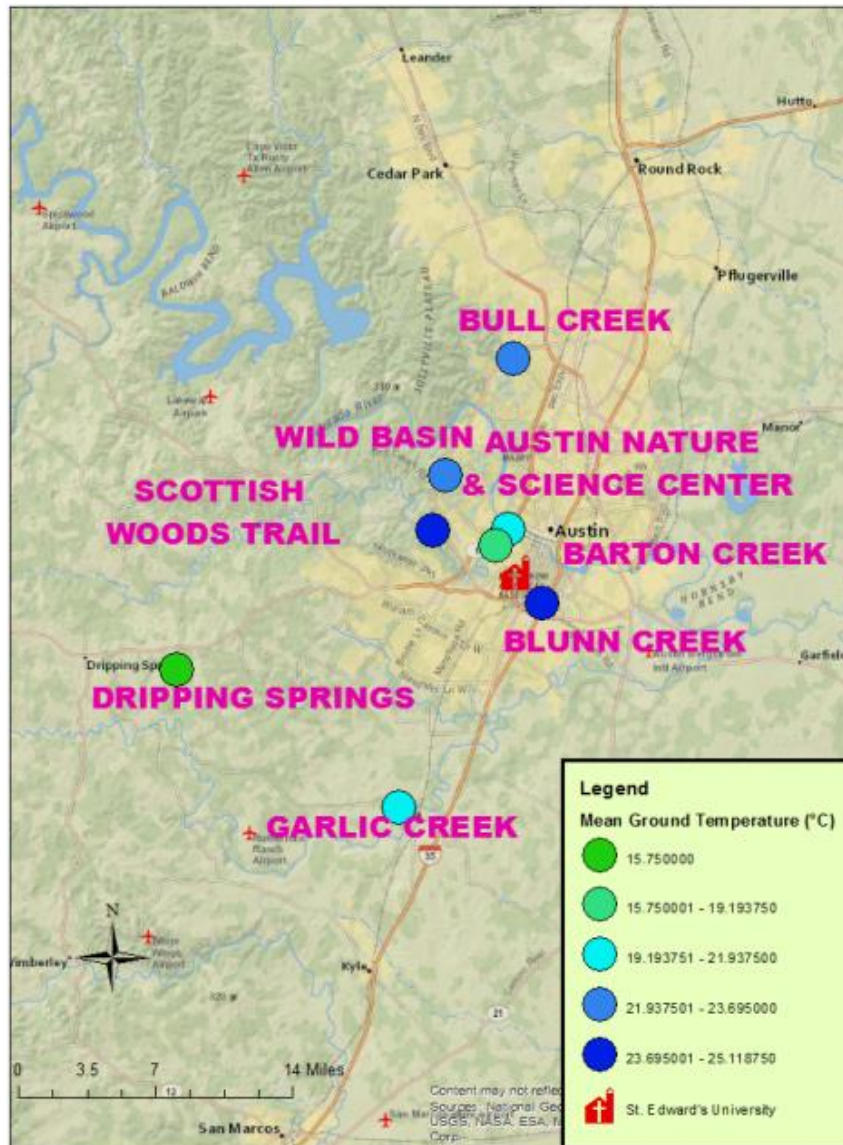
Model	95.0% Confidence Interval for B	
	Lower Bound	Upper Bound
1 (Constant)	1.939	2.102
TICKSPRSESNECEN	-.745	-.459

**Figure 10.** Underbrush level - simple linear regression.



**Figure 11.** ArcGIS map depicting the mean underbrush level at each site. Note that Bull Creek, Wild Basin, and the Scottish Woods Trail at Barton Creek had some of the lowest underbrush.

Mean ground temperature had the fourth greatest significance out of all of the variables. It had a P-value of .000, and a correlation coefficient of  $R = .293$ . The map below was designed in ArcGIS, a digital mapping interface, allowing us to enter statistical data to be displayed on a complex map background (*Figure 12*).



**Figure 12.** ArcGIS map depicting the mean ground temperature at each site.

## Discussion

It was our goal to measure the distribution of tick populations in public parks within and close to Austin, Texas. It was also our intention to determine any correlation between the presence of ticks and any environmental variables that were measured. Carbon dioxide (CO<sub>2</sub>) traps and tick drag nets were used to capture the tick samples. These are methods that have been used by entomologists and other public health workers in the past. Some other methods include live-baiting traps, or putting a small live animal (typically rats or mice) in a mesh wire cage in the middle of the plywood board trap, then allowing ticks to get stuck on the tape. The “bait” (live animal) is also checked for ticks. Another method is live trapping, in which researchers trap birds, rodents, reptiles, deer, or other common host species, and they are checked for ticks. This can sometimes be done as a secondary study to research that is already being done.<sup>15,16,17,18</sup> These are also good methods because it gives a better idea as to which species are being parasitized, by what species of tick, and what diseases are being carried by the ticks that are on these animals.

Blood samples can also be taken from the host animal(s) to determine whether or not there are any tick-borne pathogens present.

The variables that were measured include time, air temperature (°C), ground temperature (°C), humidity (%), underbrush level (0-4), light level (lux), wind speed (m/s), wind direction, distance to water and roads, and the presence or absence of ticks in that area. Most of these variables demonstrated some level of significance ( $P = .000$ ). However, most of their correlation coefficients remained relatively low. The variables with the greatest correlation when compared to tick presence/absence include: distance to road ( $R = .667$ ), distance to water ( $R = .445$ ), underbrush level ( $R = .309$ ), and ground temperature ( $R = .293$ ). Consideration was given to comparing tick densities in proximity to roads, as McEnroe found in 1971 that CO<sub>2</sub> generated by vehicles had an influence on tick distribution. This distribution was



evidenced by low tick numbers within 30 meters of the roadside, with all of the ticks being effectively drained to the direct road edge. Another aspect is that tick populations on the roadside persisted several weeks longer than in the surrounding areas. However, in our study we found the opposite result in which a correlation coefficient of  $R = .667$  and a coefficient of 548 meant that for every 548 meters further from the road that you get, the more likely you will be to find a tick.<sup>19</sup>

Proximity to water had the second greatest significance out of all of the other variables. It had a P-value of .000, a correlation coefficient of  $R = .445$ , with a coefficient of 63. This means that for every 63 meters you get further away from the primary water source, the more likely you are to find a tick. Ticks have a lifespan of up to two or three years (depending on the species and environmental conditions). In that time, as previously mentioned, the tick goes through four life stages where it only feeds at the larvae, nymph, or adult developmental phases.<sup>6</sup> In between those periods of time, the tick waits for its opportunity to latch onto a host on which it can feed. For a small tick on a single blade of grass in the middle of a forest or meadow, this process could take months, and up to 80% of ticks never make a complete life cycle due to desiccation (water loss due to a lack of blood meal or low humidity). In a complex process by which the ticks can essentially “absorb” moisture from air with high humidity levels<sup>4,6</sup>, they can maintain the necessary body moisture of about 75 - 95% to avoid desiccation.<sup>4</sup>

With that being said, we hypothesized that a tick in Texas would need to be relatively close to a water source, in areas of shade or high humidity in order to maintain this water balance. Although there was a low correlation between light level (lux) or humidity (%) and tick presence/absence, there was a more significant correlation between tick presence and the distance from a water source. According to our findings, for every 63 meters you get further



away from the primary water source, the more likely you are to find a tick. However, with a minimum distance of 8 meters, a maximum distance of 221 meters, a median of 85 meters, and a mean of 123 meters on the five days that a tick or ticks were found, there may be a maximum distance that ticks in Texas are likely be found from a water source. The Wild Basin site (camera trap 7) which was used twice in this study due to reports of high levels of tick activity, may have been an outlier at 221 meters. It was used twice in the calculations due to the fact that ticks were found on two separate days at that plot, which may have put a higher emphasis on that possible outlier. Another possibility is that since the only ticks that were found in this spot and at the third-furthest site Bull Creek were Lone Star Ticks (*Amblyomma americanum*), which have an average body moisture level of only 57.5 - 69% <sup>20</sup>, they may be less prone to desiccation in Texas and can survive in areas that are further from water and lower humidity levels.

Underbrush level had the third highest correlation in this study. It had a P-value of .000, a correlation coefficient of  $R = .309$ , with a coefficient of  $-.602$ . This means that when using the scale of 0-4 to measure underbrush level (0 = no underbrush, 4 = very tall & thick underbrush), for every 0.6 by which the 0-4 scale decreases, the more likely you are to find a tick. This is contrary to some of the literature, which states that ticks are often found to thrive in areas of tall grass.<sup>14</sup> However, they are also found in “areas of brush or leaf litter” which indicates that they can be found in a low level of underbrush.<sup>14</sup> The low levels of underbrush where we found ticks were in more shaded areas, and were typically on days of low humidity. The areas with ticks in taller grass may have been due to the shade it provided to prevent desiccation in the Texas heat.

Mean ground temperature had the fourth greatest significance with a P-value of .000, and a correlation coefficient of  $R = .293$ . This shows that there is a slight correlation between the mean ground temperature and the areas in which ticks are present. The mean ground temperature

in areas where ticks were present ranged from 21.9 - 25.1°C (71.4 - 77.2°F), which is comprised of the highest mean ground temperatures out of all the sites in this study. However, in the Karakum Desert (Balashov, 1960), adult *H. asiaticum* ticks have shown that they will actively pursue hosts and will travel several meters over the surface of the desert where humidities range from 15 - 50%, and soil temperatures can reach up to 35 - 45°C (95 - 104°F). The unfed ticks can lose water continuously, and may only survive for three to four months. Some unfed ticks can live in these conditions for more than a year; “hiding in various shelters, deep soil crevices, and often the burrows of gerbils, when soil temperatures increase beyond 40°C. The gerbil burrows and soil fissures at depths of 50 cm were stable and favorable for water vapor absorption. Diurnal temperatures ranged between 22 - 24°C and relative humidities between 84 and 100%.”<sup>4</sup> This shows how resilient some tick species can be, and how they are able to survive in high heats (such as those found in Texas) by staying in low underbrush and burrowing in vegetation, among other ways of remaining cool and retaining body moisture. It also displays the wide range of ground temperatures in which some tick species can survive.

Due to the weather conditions being unsuitable for sampling in the first few months of this project, the overall sample size of ticks collected was relatively low ( $n = 11$ ). There did appear to be some correlations made between some variables and the presence or absence of ticks. Distance to road ( $R = .667$ ), distance to water ( $R = .445$ ), underbrush level ( $R = .309$ ), and ground temperature ( $R = .293$ ) had the greatest significance, respectively, when compared to tick presence/absence. Nevertheless, the sample size is still considerably low to consider the aforementioned correlations made to be truly significant. The continuance of this study would be necessary in order to make an accurate analysis of the environmental variables when compared to tick presence / absence.

This study is not likely to be continued during the course of the Summer 2015 season. However, if this study was continued or repeated in a different fashion, it would involve the distribution of scintillation vials and information sheets to local veterinarians. The instructions would be to collect any ticks found on patients brought into the hospital, fill out the patient sheet with the owner's contact information, the pet's information (species, breed, age, etc.), and where the pet has been in the past 4-5 days where they may have gotten the tick. The ticks would then be put in the scintillation vials with 95 - 100% ethanol for preservation and either stored in the hospital freezer to be picked up by the researcher(s) or sent directly to the researchers and subsequently submitted to a lab for genetic analyses (or, if time allows, an in-house PCR analysis would be performed). Simultaneously, the same CO<sub>2</sub> traps and tick dragging procedures would be continued for the remainder of the study. Both methods were successful in catching ticks.

In the past few weeks (February 2015), a journal article was published by a researcher at UC Berkeley who did live trapping with birds in California. She discovered that birds are actually carriers of Lyme disease, and due to their current migratory patterns (and with the potential for them changing due to climate change), it could mean that tick-borne illnesses such as Lyme could be spread to other environments where it is not commonly found.<sup>21</sup>

Why is this important? Out of the 338 Nearctic-Neotropical migratory bird species in North America, 333 of them have been recorded in Texas.<sup>22</sup> Which means that 54% of the 615 bird species within Texas have the potential to transfer diseases across state lines. This brings up the fact that climate change may cause bird migration patterns to shift - as it may cause other vectors of arthropod-borne illnesses to do the same. This could potentially bring new strains, or entirely new arthropod-borne diseases closer to home.

This is not just a problem for arthropod-borne illnesses, or with changes in the global or local climate. This has to do with the need for consistent observation and systematic surveillance of ticks and their reservoir hosts - as well as other zoonotic diseases and their primary or secondary host species - to help prevent future or current (yet possibly unknown) pandemics which may start in wildlife or insects. 61% of all known infectious pathogens are zoonotic (a disease that can be transmitted from animals to humans), and 71.8% of those have origins in wildlife. Humans only act as the initial or primary reservoirs for only 3% of all zoonotic agents.<sup>23</sup> Continuing studies like this one in Texas and other states or countries can help us locate the sources of Lyme disease, other arthropod-borne diseases, as well as all other zoonotic diseases to help maintain the knowledge of their risk or prevalence in different areas around the world.

#### One World, One Health:

“... Animal health and public health are of great importance to all, and we must have good animal health to have good public health. Good public health provides a means for good animal health.” - James H. Steele, DVM, MPH

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